Effect of fertilization level and sources of potassium on zucchini fruit quality and yield components

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Abstract
The experiment was carried out at the Agricultural Research Station of the College of Agriculture / University of Kufa during the fall season 2023-2024 using an experimental area was 200m2 (20m length *10m width). to study the effect of different sources of potassium fertilizer and the quantity used on some yield quality and components of zucchini plants. The experiment was factorial RCBD with two factors and three replicates. The first factor was potassium fertilizer from three sources which are potassium sulphate fertilizer (S), potassium nitrate fertilizer (N), Grow Plus fertilizer (G). While, the second factor was fertilization at four levels of 0, 40, 80, or 120 Kg ha-1. The findings showed that fertilization with Grow Plus fertilizer at 120 Kg ha-1 was significantly superior to the other levels of potassium sources in most of the fruit quality characteristics and yield components resulting in higher fruit content of N(1.53 %) P (0.27%) and K(2.85%) of especially where using higher levels of fertlization. Best results of fruit quality and plant yield were always obtained from fertilizer Growth Plus, followed by potassium nitrate P(0.33%) and potassium sulphate K(2.58%) respectively. In most cases the fertilization with 120 Kg.h-1 resulted in better indicator valeu regardless the type of fertilizer used.
Keywords: cucurbits, fertilizers, potassium sulphate, potassium nitrate, Growthplus

INTRODUCTION

Fertilizers in most cases must contain a certain level of pottsium to be completely benificial for plant growth, flowering and fine yield. Potassium (K) is one of the major nutrients necessary for plants, as it activates more than 60 enzymes that contribute to important plant activities. It has an important role in the process of photosynthesis as well as transporting water and nutrients to other parts of the plant [1,2]. Potassium has several functions in plant cells, including biophysical functions, such as increasing tolerance to various environmental stresses such as heat, drought, salinity, and osmoregulation. Potassium also contributes to photosynthesis, as it contributes to transporting the products of the photosynthesis process and storing them in the form of proteins and fats in crop grains as well There is a role for potassium in resisting diseases and insects, as well as in plant resistance to drought, reducing water loss, and preventing wilting [3]. K is found in large quantities in young plant organs with active growth, especially buds, young leaves, and the tops of roots. In the cell fluid and cytoplasm, while potassium is low in concentration in seeds and mature tissues. K moves quite freely through

ISSN 2072-3857

tissues; Thus, the plant can reuse it again by moving it from old tissues to developing tissues. In addition, potassium can reduce the toxic effects of abiotic stresses in crops [4].

The zucchini plant (*Cucurbita pepo* L.) is a summer vegetable crop belonging to the Cucurbitaceae family, and it is one of the crops that is widely cultivated in Iraq, especially in the spring and fall seasons, in addition to being grown in greenhouses in the winter [5] . Zucchini is grown during the summer in tropical and subtropical conditions in the world [6]. The total cultivated area in the world reached 2,078,450 hectares, with a productivity of 27,449,481 tons [7]. The total zucchini cultivated area in Iraq was estimated to more than 2,100 hectares with a yield rate of 9,384 Kg ha^{-1} [8] . Because the zucchini plant is a fast-growing crop with an early production life, the plant needs good, precisely directed nutrition to ensure growth and yield. The highest possible level during the agricultural season. Therefore, this styudy aimed to evaluate zucchini plants response in terms of yield quality and yield components to different types of potassium fertilizer at different fertilization levels.

Materials and Methods

Experiment location: A field experiment was conducted in one of the greenhouses in the agricultural research station belonging to the College of Agriculture / University of Kufa during the agricultural season (autumn) In Protected homes for the year (2023) starting on 9/7 using an experiment field area of 200 m^2 (20 m long * 10 m wide).

Soil analysis:Soil samples were taken randomly from the experimental field collected at depth 0-30 cm, mixed well and three representative samples were air dried and subjected to soil analysis for some physical and chemical characteristics of the soil (Table 1).

Table1. Some physical and chemical characteristics of field soil before planting

Particle	Result	Unit
Clay	60	
Silt	68	g Kg^{-1}
Sand	872	
Texture	Sand loam	
Property	Value	Unit
EC	1.562	$dS.m^{-1}$
Ph	.317	---------
N	41.6	
P	61.14	mg Kg^{-1}
K	88.88	

Experiment general procedure: The field was divided into 10 rows, 150 cm between the middle of each two successive rows. Zucchini seeds It is a hybrid type (308f1) were planted 3 seeds per jura with 30 cm planting distances. The experiment units were distributed as RCBD with three replications. As the treatments were two factors, The first is the type of fertilizer from three sources of potassium fertilizer, with four levels for each one: potassium sulphate K_2SO_4 fertilizer (S0, S1, S2, and S3), potassium nitrate KNO_3 fertilizer (N0, N1, N2, and N3) and Grow Plus fertilizer (G0, G1, G2, and G3). The second factor was the fertilizer levels for each type, which are 0, 40, 80, or 120 Kg ha^{-1}.

Studied indicators

Studied indicators

Fruit content of nutrients: The percentage of nutrients (N.P.K) in the fruits was determined. The percentage of nitrogen in the fruits (%) was estimated using the Kjeldal device in 10 ml of the digested sample and using the ammonia-HCl method of 0.04 titration [9]. The percentage of phosphorus in fruits (%) in 10 ml of digested sample was estimated using optical absorption spectrophotometer at a wavelength of 620 nm and calibrating the results with the phosphorus standard curve)[9]. The potassium content of fruits (%) was also estimated using the Flame Photometer method [9].

Yield indicators

Early yield (Megag h^{-1}): The amount of early yield was calculated for the yield of the first three harvests, and then attributed to the hectare. The first, second, and third harvest dates were October 10, 17, and 21, 2023, respectively.

Plant yield (g $plant^{-1}$): The average yield per plant (g $plant^{-1}$) was also calculated The average yield of seeds per plant (g $plant^{-1}$) was also calculated for seed yield of all experimental unit divided by the number of plants.

Total yield (ton ha^{-1}): The zukcini was harvested every seven days, as only marketable fruits were counted. The final cumulative sum of all harvests throughout the experiment duration till 1/20/2024 was caculated. The total yield for the experimental unit was extracted and then attributed to the hectare:

Total yield (ton ha^{-1})= (experimental unit yield * hectare area)/experimental unit area[27].

RESULTS AND DISCUSSION

The results indicated that the Grow Plus fertilizer resulted in highest increase fruit content of nitrogen (Table 2), phosphorus (Table3), and potassium (Table 4) with significant difference ($P \leq 0.05$) compared to the other two types of potassium fertilizer. The results indicate that the nitrogen content of fruits recorded the highest rate of 1.53% in the potassium nitrate fertilization treatment, KNO3, with a significant difference of P<0.05 compared to the type of potassium fertilizer, while the Grow Plus treatment recorded the lowest rate of 1.06%. The nitrogen content of thar did not differ between the two types of potassium sulphate K2SO4 fertilizer and Grow Plus fertilizer. Regarding fertilization levels, (80 kg ha-1) recorded the highest rate of 1.86% nitrogen content of fruits. It was also noted that the highest rate of nitrogen content in fruits, 2.00%, was in the treatment (80 kg ha-1) using (Grow Plus), which usually did not differ from the same level of fertilization using other fertilizers.

ISSN 2072-3857

Table2. Effect of source quality and application level of potassium fertilization on fruit content of nitrogen % in autumn zucchini

Potssium fertilizer	Fertilizer level (Kg. h^{-1})				Average
	0	40	80	120	
Growth Plus	1.11 ef	1.15 e	2.00 a	1.87 ab	1.06 A
KNO_3 (PN)	1.05 f	1.45 d	1.94 a	1.70bc	1.53 A
K_2SO_4 (PS)	1.01 f	1.37 d	1.65 c	1.93 a	1.49 A
Average	1.53 C	1.32 B	1.86 A	1.84 A	

*Values are means of three replications, means among treatments interactions (lower case) or within averages column and/or rwo (upper case) followed by different letter(s) are significantly different according to Duncan's multiple range tests ($P \leq 0.05$).

Measuring the percentage of phosphorus in fruits (%)

The results indicate an increase in the phosphorus content in fruits due to the effect of fertilization treatments (Table 3). Potassium nitrate KNO3 fertilizer recorded the highest phosphorus content in fruits, 0.33%, with a significant difference of P<0.05 compared to other types of potassium fertilizers. The potassium sulfate K2SO4 treatment recorded the lowest rate of 0.30%. The phosphorus content of fruits did not differ between Grow Plus and potassium sulphate K2SO4.

The results of the same table indicate that there are significant differences between the levels of potassium fertilizer from different sources, as the level (120 kg ha-1) recorded the highest rate of 0.42% compared to the level without adding potassium fertilizer (0 kg ha-1). As for the interaction between the quality and level of potassium fertilizer, the highest rate of phosphorus content in fruits was 0.45% at (80 kg ha-1) of (KNO3

Table3. Effect of source quality and application level of potassium fertilization on fruit content of phosphorus % in autumn zucchini

Potssium fertilizer	Fertilizer level (Kg. H^{-1}				Average
	0	40	80	120	
Growth Plus	0.20 e	0.31 c	0.31 c	0.43ab	0.31 AB
KNO_3 (PN)	0.20 e	0.27 cd	0.45 a	0.40 b	0.33 A
K_2SO_4 (PS)	0.20 e	0.25 d	0.31 c	0.43ab	0.30 B
Average	0.20 D	0.28 C	0.36 B	0.42 A	

*Values are means of three replications, means among treatments interactions (lower case) or within averages column and/or rwo (upper case) followed by different letter(s) are significantly different according to Duncan's multiple range tests ($P \leq 0.05$).

Fruit content of potassium (%)

It was also found that the Grow Plus fertilization treatment recorded the highest rate of potassium content of fruits, 58%, with a slight difference from other fertilization treatments, especially the potassium sulphate K2SO4 treatment, with the lowest rate of 2.36%. It is also noted from Table (4) that the fruits potassium was always higher in the fertilization treatment at the highest level (120 kg ha-1). In general, the highest rate of potassium content in fruits was 3.70% where fertilizing 120 kg ha-1 with (K2SO4), with a very slight difference compared to fertilizing with other types of fertilizer at the same level used.

Table4. Effect of source quality and application level of potassium fertilization on fruit content of potassium % in autumn zucchini

Potssium fertilizer	Fertilizer level (Kg. h^{-1})				Average
	0	40	80	120	
Growth Plus	2.00 cd	2.45 c	2.54 bc	3.33ab	2.58 A
KNO_3 (PN)	1.75 cd	2.40 c	2.39 c	3.58 a	2.53 A
K_2SO_4 (PS)	1.49 d	2.10 cd	2.13 cd	3.70 a	2.36 A
Average	1.75 C	2.32 B	2.35 B	3.54 A	

*Values are means of three replications, means among treatments interactions (lower case) or within averages column and/or rwo (upper case) followed by different letter(s) are significantly different according to Duncan's multiple range tests ($P \leq 0.05$).

The use of different types of fertilizers increases the effective state of nutrients in the soil, which affects the soil pH [4]. There are also interactive and competitive effects between the various nutrients found in the soil, which directly affect the absorption of nutrients and their use by the plant. It is worth noting that these effects are also linked to the type of plant and the stage of growth [10]. Sources specialized in physiology indicate Plant and its nutrition: The distribution of nutrients in the plant body is not homogeneous, but rather varies depending on the part and plant tissue. In general, leaves and new growth contain high amounts of NPK elements compared to older parts or leaves [1]. It was observed that the amount of nitrogen in fruits increases with increasing fertilization level. Nitrogen is the most important nutrient for plants. It helps increase the plant's efficiency in absorbing the necessary nutrients from the soil, which positively affects the plant's yield. N also participates with Mg to form the chlorophyll molecule, where N is an important element in this aspect, in addition to being involved in the formation of hormones, vitamins, and enzymes. The availability of nitrogen leads to increasing the efficiency of plants in consuming water, resisting external stresses, delaying aging, and prolonging the life of the plant. Nitrogen regulates the action of plant hormones (auxins and cytokines), which leads to an increase in meristematic cell divisions responsible for growth, and then leads to an increase in the size of the plant's shoot and flower production, as well as an increase in the size of the root system [11][12][13]. The increase in phosphorus content in fruits is also affected by the level of fertilization. This is due to the increase in the quantity and quality of potassium fertilizers added, and the efficiency of the readiness of phosphorus absorption by the roots from the beginning of the plant's life, which helped to strengthen and revitalize the root system by supplying the plant with the water and nutrients it needs, including phosphorus,

ISSN 2072-3857

which led to an increase in its concentration in the fruits [12]

Increasing the level of fertilization also led to an increase in the potassium content of the fruits. The increase in NPK concentrations in leaves and fruits may be attributed to the type and quantity of potassium fertilizer added to the soil, as this has become a scientific fact, especially in soils with low or medium content of these nutrients. Higher levels of fertilization (120 and 80 kg ha-1) concentration of NPK elements showed a clear increase in potassium in the fruits. This is because the amount of potassium in the experimental soil is low to medium in potassium content[14] . This result is consistent with what [15] [16].

Early yield (ton h^{-1})

Regarding the effect of the types of fertilization on the amount of early yield of the first three harvests, it was found that potassium sulfate K2SO4 fertilization led to a higher early yield than the other types of fertilization, recording 9.27 t h-1, while the potassium nitrate KNO3 treatment recorded the lowest rate of 8.88 t h-1 (Table 5) . Grow Plus and K2SO4 did not differ much in this indicator. The early yield rate always recorded higher values at the highest fertilization level (120 kg ha-1), regardless of the type of fertilizer. The highest early yield rate of 11.363 kg ha-1 was in the intervention treatment (120 kg ha-1) and (KNO3) (Table 5)

Table5. Effect of source quality and application level of potassium fertilization on early yield (the earliest 3 harvests) of autumn zucchini

Potssium fertilizer	Fertilizer level (Kg. h^{-1})				Average
	0	40	80	120	
Growth Plus	7.417 e	8.563d	10.107 bc	10.75abc	9.2092 A
KNO_3 (PN)	6.723 e	7.7 de	9.767 c	11.363 a	8.8883 A
K_2SO_4 (PS)	7.383 de	8.67 d	11.087 ab	9.94 c	9.27 A
Average	7.174 C	8.311 B	10.32 A	10.684 A	

*Values are means of three replications, means among treatments interactions (lower case) or within averages column and/or rwo (upper case) followed by different letter(s) are significantly different according to Duncan's multiple range tests ($P \leq 0.05$).

Yield per plant (kg $plant^{-1}$)

Regarding the effect of treatments on the average plant yield (kg plant-1), the results (Table 6) indicate that there is an increase in the average plant yield when using Grow Plus, which recorded 2.86 kg plant-1 with significant differences (P<0.05) compared to other types of potassium fertilizers. . In fertilization with potassium sulfate K2SO4, the lowest rate was 2.22 kg plant-1. Potassium nitrate KNO3 did not differ from Grow Plus fertilizer. In general, the level (80 kg ha-1) recorded the highest rate of 3,550 kg plant-1 compared to the other levels. However, with regard to the interaction between the quality and level of fertilizer, the plant response differed. The highest average yield per plant was 4.26 kg plant-1 where using 120 kg ha-1 of Grow Plus.

ISSN 2072-3857

Table6. Effect of source quality and application level of potassium fertilization on plant yield (Kg plant^{-1}) of autumn zucchini

Potssium fertilizer	Fertilizer level (Kg. h^{-1})				Average
	0	40	80	120	
Growth Plus	1.22e	2.67e	3.30b	4.26a	2.86A
KNO_3 (PN)	1.22e	2.33d	3.17b	4.26a	2.77B
K_2SO_4 (PS)	1.29e	2.20d	4.17a	1.22e	2.22C
Average	1.282D	2.398C	3.242B	3.550A	

*Values are means of three replications, means among treatments interactions (lower case) or within averages column and/or rwo (upper case) followed by different letter(s) are significantly different according to Duncan's multiple range tests ($P \leq 0.05$).

Total yield (ton.h^{-1})

The results shown in table (7) indicate an increase in the total yield rate, as the type of Grow Plus fertilizer was superior ($P<0.05$) compared to the other types of potassium fertilizers. It is also noted that total yield didn't differ between potassium nitrate KNO3 fertilizer and potassium sulphate K_2SO_4. Significant differences were also recorded between the levels of potassium fertilizer from different sources, as the level of 120 kg ha^{-1} recorded the highest rate of total yield of 14.06 kg ha^{-1} when using Grow Plus.

Table7. Effect of source quality and application level of potassium fertilization on total yield (ton ha^{-1}) of autumn zucchini

Potssium fertilizer	Fertilizer level (Kg. ha^{-1})				Average
	0	40	80	120	
Growth Plus	8.82e	10.77cd	12.41b	14.06a	11.52A
KNO_3 (PN)	8.83e	10.48cd	11.22c	12.79b	10.83B
K_2SO_4 (PS)	9.11e	10.16d	12.39b	11.14c	10.70B
Average	8.92D	10.47C	12.01B	12.66A	

*Values are means of three replications, means among treatments interactions (lower case) or within averages column and/or rwo (upper case) followed by different letter(s) are significantly different according to Duncan's multiple range tests ($P \leq 0.05$).

The findings confirmed the possitive response of zucchini yield and fruit quality to potassium fertilization. This is mostly due to the low K content avialable for plants in the untreated field soil compared to the provided K. Although K in the Iraqi soil in relative abundance, recommendation for potassium fertilization in Iraq is not exactly determined and remain unclear. Potassium is at high inportance for plant nutrition and physiological processes, it contributes to the synthesis and construction of enzymes, as well as its contribution to controlling and regulating osmotic pressure in the cytosol [17]. Potassium participates in more than 80 enzymes in the plant and creates amino acids, which form the basis for building growth hormones and acetic acid, which is responsible for cell elongation and root strengthening[17].

ISSN 2072-3857

Potassium is also involved with nitrogen in the production of auxins, which have a direct effect in increasing cell division and elongation and increasing the activity of meristematic apices. In addition to the readiness of the basic materials that the plant needs in the construction process, such as amino acids and enzymatic conjugates such as DNA and PDNA, which contain higher levels of nitrogen [18][19]. The presence of potassium in sufficient quantities had an effect in increasing plant growth, as well as cell division, encouraging tissue growth, and then the growth of the root system, increasing nutrient absorption, and its positive effect in increasing the transport and movement of proteins in the plant stem and leaves, and this was reflected positively with the increase in plant growth and productivity [20] [21][16][22].

The fertilization process through ground application aims to increase the overall productivity of the plant, as fertilizers provide the plant's need for the necessary nutrients necessary for vegetative growth and thus production. The increase in yield indicators can be attributed to the important role of potassium in activating various enzymatic systems, regulating the osmotic pressure of cells, and the process of opening and closing stomata. The cells formed in the presence of potassium have thicker walls, and the role of these factors is important in increasing fruit weight and yield [23]. In fact, the plant at its physiological activity during the stage of fruitful growth (yield production), requires high amounts of potassium to perform such vital processes. Providing potassium at such time helped increase the number of fruits and total production, as the effective effect of adding potassium was observed in increasing total production, especially the yield per plant and the total yield [24][25]. It is also noted that there is a significant improvement crop total yield due to potassium frtilization especially where used at higher levels. As potassium plays an important role in increasing the total vegetative growth, which reflects positively on the amount of plant yield and the total yield, and thus increase in the productivity of the cultivated area [26].

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ISSN 2072-3857